Chemical Engineering Thesis Defense

Idiographic Models of Walking Behavior for Personalized mHealth Interventions: Some Novel Approaches

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Abstract

This thesis presents the development of idiographic models (i.e., single subject or N=1) of walking behavior as a means of facilitating the design of control systems to optimize mobile health (mHealth) interventions for sedentary adults. Model-on-Demand (MoD), an adaptive modeling technique, is demonstrated as an ideal method for modeling nonlinear systems with noise on a simulated continuously stirred tank reactor (CSTR). Comparing MoD to AutoRegressive with eXogenous input (ARX) estimation, MoD outperforms ARX in terms of addressing both nonlinearity and noise in the CSTR system. With the CSTR system as an initial proof of concept, MoD is then used to model individual walking behavior using intervention data from participants of HeartSteps, a walking intervention that studies the effect of within-day suggestions. Given the number of possible measured features from which to design the MoD models, as well as the number of model parameters that influence the model's performance, optimizing MoD models through exhaustive search is infeasible. Consequently, a discrete implementation of simultaneous perturbation stochastic approximation (DSPSA) is shown to be an efficient algorithm to find optimal models of walking behavior. Combining MoD with DSPSA, models of walking behavior were developed using participant data from Just Walk, a day-to-day walking intervention; MoD outperformed ARX models on both estimation and validation data. DSPSA was also applied to ARX modeling, highlighting the use of DSPSA to not only search over model parameters and features but also data partitioning, as DSPSA was used to evaluate models under various combinations of estimation and validation data from a single participant's walking data. Results of this thesis point to ARX with DSPSA as a routine means for dynamic model estimation in large-scale behavioral intervention settings.

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